

Salvagability of Giant hydronephrosis ,Non Visualised on IVU

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CERTIFICATE

This is to certify that this dissertation entitled

“Salvagability of Giant Hydronephrosis ,non-visualised on IVU”

is a bonafide record of the research work done by **Dr.N.Sudhakar** for the award of MCh Genitourinary surgery, under the supervision of **Dr.R.Radhakrishnan MCh** , Professor & HOD , Urology, Government Stanley Medical College, Chennai between 2005 and 2008.

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“Salvagability of Giant Hydronephrosis ,non-visualised on IVU”

was prepared by me in the Department of Urology, Government Stanley Medical

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INTRODUCTION

. *Hydronephrosis* should be used as a descriptive term referring simply to the presence of dilatation of the pelvis and calyces and not to the cause of that dilatation

The presence of over 1000 ml of urine in a hydronephrotic sac in an adult is usually categorised as giant hydronephrosis. Yang et al (1958) ⁽¹⁾ opined that the term giant hydronephrosis should be used only when the contents of the sac equalled to average daily urine output for that age. Giant hydronephrosis has also been defined as kidney that occupies a hemiabdomen, which meets or crosses the midline and which is at least 5 vertebrae in length.⁽²⁾

Congenital ureteropelvic junction (UPJ) obstruction is the commonest cause of giant hydronephrosis in children and adults. Occasionally, it occurs as a result of ureterovesical junction obstruction. ⁽³⁾ Other causes include obstructive megaureter, ureteric atresia⁽⁴⁾ and obstructive ectopic ureter with or without a duplex system. These Giant hydronephrosis usually present in middle age and the main therapeutic challenge is whether to go ahead with ablative or salvage procedure. All patients with giant hydronephrosis do not have similar anatomical configuration and functional status of renal units, and therefore treatment has to be individualized in every patient. Hence

assessing the salvagability of these kidneys becomes all the more important.

We have found that most of these cases show non excretion of contrast in IVU. Though nonvisualisation on IVU may indicate critical loss of function, the renal unit cannot be branded as “Nonfunctional “.

We have selected such cases for further evaluation with Doppler, Diuretic renogram, USG for cortical thickness and Percutaneous nephrostomy. Our aim was to study all these factors and conclude which investigation gives the best assessment of salvagability

We favour percutaneous nephrostomy if patient is febrile and/or serum creatinine is elevated or IVU shows non-visualized unit or pelvicalyceal system is not well delineated. Further, based upon overall functional status, ablation of unit or reconstructive surgery is planned. The type of reconstruction is individualized as per anatomical configuration demonstrated on antegrade study or IVU.

2. REVIEW OF LITERATURE

The term *hydronephrosis* is derived from *hydro* (from the Greek *hydor*, "water"), *nephros* (Greek "kidney"), and *osis* ("condition") and is generally defined as dilatation of the renal pelvis and calyces resulting from obstruction to the flow of urine. Because

dilatation of the renal pelvis and calyces can occur without obstruction, this definition is not completely accurate. *Hydronephrosis* should be used as a descriptive term referring simply to the presence of dilatation of the pelvis and calyces and not to the cause of that dilatation. The basic function of the kidney is the formation of an ultrafiltrate that is free of protein and yet contains appropriate amounts of water, electrolytes, and the end products of metabolic pathways to maintain homeostasis. Once this occurs, the remaining portions of the urinary tract function either to eliminate or to store urine or both. When there is a structural impedance to the flow of urine anywhere along that tract, it can be described as *obstructive uropathy*. The term *obstructive nephropathy* should be reserved for the damage to the renal parenchyma that results from an obstruction to the flow of urine anywhere along the urinary tract.. The terms *obstructive uropathy* and *hydronephrosis* should not be used interchangeably. Obstruction is reviewed in terms of the radiographic, anatomic, and physiologic changes that occur within the kidney .

Obstructive uropathy with resultant Hydronephrosis is the eventual outcome of many urological disorders , PUJ obstruction being common and important. The accurate prediction of the recoverability after relief of chronic partial obstruction is of great clinical value to the urologist and nephrologists. If restoration or improvement of renal function is possible, surgical relief of obstruction is possible, even though there may be initial loss of function. There are various factors to assess the functional recoverability and each shall be studied individually.

ANATOMIC CHANGES OF THE UPPER URINARY TRACT WITH OBSTRUCTION

Unilataeral ureteric obstruction (UO) is accompanied by changes in the architecture of the kidney. The most prominent interstitial change is fibrosis, the accumulation of collagens and other extracellular matrix components. Along with fibrosis are changes in the cellular composition of the interstitium, as well as changes in the expression of a myriad of other biologically active molecules.

It has been postulated that by obliterating tubules and interstitial capillaries, interstitial fibrosis may be a major determinant of the decreased renal function in many renal diseases. ⁽⁵⁾

Experimental strategies targeting changes in the interstitium are being developed. These strategies will conceivably have a future role as a medical adjunct to the management of Unilateral Ureteric Obstruction.(UUO)

Gross Changes in the Human Kidney

The appearance of the kidney after ureteral obstruction varies with the presence of an intrarenal versus extrarenal collecting system, the length and degree of obstruction, and the presence or absence of infection. The presence of the renal parenchyma completely around an intrarenal collecting system limits its ability to dilate. Expansion of an

extrarenal collecting system, however, is not limited by the renal parenchyma.

Therefore, the intrarenal system, although obstructed to the same degree and duration as the extrarenal system, may not exhibit the same degree of hydronephrosis; however, the degree of renal damage may be worse.

Acute complete ureteral occlusion may cause little change in the collecting system, especially if there is an intrarenal collecting system; it may take several days to develop significant collecting system dilatation under these conditions. Chronic obstruction can produce an enlarged, normal, or atrophic

kidney, again depending on the length and degree of obstruction, as well as the presence of an intrarenal or extrarenal collecting system⁽⁶⁾. Usually, the collecting system dilates with time, especially with extrarenal collecting systems, resulting in gradual compression of the renal papilla. Over time, the collecting system enlarges to the point that the tissue between the calyces thins, resulting in calyceal enlargement. Ultimately, the calyces coalesce, with thin septa between them and a "rim" or "shell" of parenchyma remaining peripherally.

Gross Changes in the Kidney—Experimental

Extensive data on the experimental creation and investigation of hydronephrosis are available. Hydronephrosis has been shown to develop in rabbits as early as 1 day after

ureteral ligation associated with an increase in kidney weight and loss of papillary and medullary structures⁽⁷⁾. There was a steady and progressive increase in renal weight and pelvic fluid volume in these rabbits up to 4 months after ureteral ligation. This has been noted by other investigators using different animal species and models of ureteral occlusion, dating from. Strong (1940) ⁽⁸⁾ noted a subsequent decrease in kidney weight and volume of renal pelvic fluid beyond 90 days of complete ureteral obstruction, in contrast to the steady increase in these parameters demonstrated by others. By 231 days of obstruction, the weight and size of the kidney had returned to a baseline value equal to those of the contralateral nonobstructed kidney. There was a marked thinning of the renal parenchyma to a shell with little normal architecture at this time compared with the normal kidney. Ladefoged and Djurhuus (1976) ⁽⁹⁾ also demonstrated a marked decrease in kidney weight compared with the contralateral kidney with obstruction of 5 to 6 weeks' duration. Grossly, the kidney was still enlarged and cystic-appearing.

Microscopic Changes in the Kidney—Experimental

Initially, most of the microscopic changes are confined to the tubules, with little effect on the glomeruli (Sheehan and Davis, 1959) ⁽¹⁰⁾. The glomeruli seem relatively resistant to change except for a slight increase in size and a thickening of Bowman's capsule. The development of hyalinization and connective tissue proliferation are not seen until 231 days of ureteral ligation, and only in relatively few glomeruli (Strong, 1940). The tubules initially undergo dilatation of the lumen with flattening of the epithelium. After

approximately 21 days of obstruction, there are barely discernible tubules in several areas of the renal parenchyma on microscopic section.

Heyman and associates (1997) examined the effects of 24 hours of obstruction on regional renal tissue damage in rats ⁽¹¹⁾ . After 24 hours of Unilateral Ureteric Obstruction, hemorrhage and necrosis of the papilla and fornix of the kidney were found. Cells undergoing apoptosis were detected as early as 30 minutes after obstruction. There was mild damage to thick ascending limbs, and this was increased by concomitant treatment with indomethacin. However, indomethacin treatment also attenuated inner medullary damage. Contrast medium (iothalamate) administration augmented inner medullary damage in Unilateral Ureteric Obstruction. Thus, interventions for the treatment or diagnosis of renal colic may be potentially harmful to the obstructed kidney.

Fibrosis

Nagle and Bulger (1978), using electron microscopy, described the appearance of collagen fibers in the kidney by 7 days after Unilateral Ureteric Obstruction, with an increase for up to 32 days ⁽¹²⁾ . At 32 days, diffuse interstitial collagen was found in the cortex and outer medulla. Sharma and colleagues (1993) studied the immunohistochemical localization of collagen subtypes and used in situ hybridization to localize collagen mRNA in rabbits with 16 days of Unilateral Ureteric Obstruction ⁽¹³⁾ ..

Glomerular fibrosis was not prominent, with only small changes in collagen I being found .

Collagen synthesis rates have not been measured in rats in Unilateral Ureteric Obstruction. However, collagen degradation has been examined. In rats with 15 days of Unilateral Ureteric Obstruction, collagenolytic activity of renal tissue from obstructed animals was decreased by a factor of 10, compared with normal and contralateral kidneys (Gonzalez-Avila et al, 1988) ⁽¹⁴⁾ . The matrix metalloproteinases are a group of enzymes involved in the degradation of both collagen and other extracellular matrix components. The activity of the matrix metalloproteinases is controlled in part by inhibitors called tissue inhibitors of metalloproteinases (TIMPs) (Denhardt et al, 1993) ⁽¹⁵⁾ . More recent studies have examined the cellular localization and time course of expression of TIMPs. As early as 24 hours after UUO, TIMP-1 was found in an unidentified population of renal interstitial cells. From day 5 on, TIMP was expressed by interstitial myofibroblasts, macrophages, and neutrophils (Duymelinck et al, 2000). ⁽¹⁶⁾

TUBULAR CHANGES IN UNILATERAL URETERAL OBSTRUCTION

The changes in tubule function after correction of ureteropelvic junction obstruction have been well characterized. . Gillenwater and associates (1975) presented data on 10 patients with UUO; 7 had obstructions secondary to a ureteropelvic junction obstruction, and 3 had ureteral obstruction ⁽¹⁷⁾. The symptoms lasted from 2 days to 36 months; the

average period was about 12 months. The degree of obstruction was graded as moderate to severe in all cases. The patients' ages ranged from 7 to 38 years, with a mean of 23.8 years. Function in the obstructed kidney was evaluated 1 week after the relief of obstruction. The GFR in the obstructed kidney was significantly less than that in the nonobstructed kidney: 24 versus 60 ml/min, respectively ($P < .0002$). The GFRs in the obstructed kidneys ranged from 8 to 50 ml/min; the GFRs in only 3 kidneys were below 20 ml/min. The mean urine osmolality, absolute osmolar clearance (C_{osm}), and absolute and fractional free water clearances were all significantly less in the obstructed kidney. The fractional osmolar clearances ($C_{\text{osm}}/\text{GFR}$) were not different in the two kidneys.

Therefore, a true concentrating defect existed between the obstructed and the nonobstructed kidneys 1 week after relief of obstruction. However, no patients experienced a significant postobstructive diuresis. The absolute sodium excretion was lower from the obstructed kidney; however, the fractional sodium excretion was the same. This salt excretion was resistant to pretreatment of the patient with desoxycorticosterone acetate. There was no difference in the fractional titratable acid or ammonia excretion in either kidney in five of the seven patients. Proximal tubular transport measured by T_{mPAH} was also impaired after ureteral obstruction. However, when it was adjusted for the decrease in the GFR secondary to the obstruction, there was no difference between the two kidneys. **In rare cases in which the GFR is preserved,**

clinically significant water loss necessitating IV replacement can occur (Schlossberg and Vaughan, 1984). ⁽¹⁸⁾

Similar tubular changes have been observed after the release of Unilateral Ureteric Obstruction in rats (Harris and Yarger, 1974; Dal Canton et al, 1977) ⁽¹⁹⁾ . However, during partial UUO, especially early, before tubular damage occurs, there is actually a decrease in sodium and water excretion with a resultant increase in urine osmolality, similar to changes found in renal artery stenosis (Suki et al, 1971; Wilson, 1980). ⁽²⁰⁾

Several studies suggested that the increased excretion of water and salt after UUO occurs in either deep nephrons or the collecting duct of superficial nephrons (Buerkert et al, 1976, 1978) ⁽²¹⁾. However, Buerkert and coinvestigators (1979) were able to show with micropuncture studies that the collecting duct's ability for reabsorption and its permeability to water were not altered by acute ureteral occlusion. Therefore, the more likely location for the increased sodium excretion is the deep juxtamedullary nephron.

Jaenike and Bray (1960) ⁽²²⁾ were able to produce a concentrating defect in the unilaterally obstructed kidney after only 6 minutes of ureteral occlusion. Kessler (1960) ⁽²³⁾ was able to demonstrate a concentrating defect in the obstructed kidney within 5 to 8 minutes of ureteral occlusion. The administration of large doses of antidiuretic hormone restored the concentrating ability and the papillary chloride concentration in saline-

loaded animals. This observation is contrary to that of other investigators, who have found the concentrating defect in the ipsilateral kidney of UUO to be antidiuretic hormone-resistant. Solez and associates (1976) ⁽²⁴⁾ observed a marked decrease in urine osmolality in dehydrated rats after relief of 18 hours of UUO, not in association with a concomitant increase in urine output. They found a significant decrease in inner medullary plasma flow during 18 hours of UUO, and the flow increased after the release of ureteral occlusion. Histologic study revealed necrosis of both the inner and the outer medullae. It may be this physical effect of obstruction on the medulla that results in a decreased ability of the post-UUO kidney to concentrate urine.

Hanley and Davidson (1982) ⁽²⁵⁾ also described an inability of the kidney to concentrate urine after obstruction. This inability to concentrate the urine was associated with an inability of the cortical collecting tubule to respond to either antidiuretic hormone (vasopressin) or cAMP stimulation; there was a 76% reduction in the response of the collecting tubule to either stimulus. As previously described, there is an increase in prostaglandin E₂ (PGE₂) production with UUO. **It is also known that PGE₂ can inhibit the tubular effects of vasopressin, increasing free water losses from the post-UUO kidney** (Grantham and Orloff, 1968). ⁽²⁶⁾

The characterization of the aquaporins, a family of membrane water channels, provides a molecular basis for transmembrane water movement (Nielsen et al, 1999) ⁽²⁷⁾.

Aquaporin Aquaporin-2 is the predominant vasopressin-sensitive water channel of the collecting duct. Consistent with the decreases in aquaporin was a greatly increased free water clearance in the obstructed kidney.

The kidney has an impaired distal hydrogen ion secretion after obstruction. This is seen as a lack of an increase in carbon dioxide partial pressure (PCO_2) during bicarbonate loading, as well as an impaired urinary acidification with the administration of sodium sulfate. The post obstruction kidney has a higher bicarbonate reabsorption rate than the contralateral kidney (Thirakomen et al, 1976) ⁽²⁸⁾ .

After the release of UUO, the fractional excretion of phosphate is markedly decreased (3.4%) in the obstructed kidney, whereas it is increased (35.3%) in the healthy kidney. This was accompanied by a twofold greater fractional excretion of sodium in the obstructed kidney than in the control kidney. However, the decrease in phosphate excretion is believed to be secondary to a decreased filtered load of phosphate. The increased excretion of salt and water is secondary to a decreased reabsorption in the distal nephron without a concomitant decrease in proximal reabsorption (Purkerson et al, 1974).

Harris and Yarger (1975) described a marked decrease in urinary potassium excretion from the ipsilateral kidney after 24 hours of UUO. With micropuncture studies, Yarger

and Griffith (1974) ⁽²⁹⁾ found a decrease in both the absolute and the fractional excretion of potassium after 24 hours of UUO. This suggests that the decrease in potassium excretion does not result from a decrease in the filtered load of potassium. Explanations for the decrease in potassium excretion would be that the distal tubular volume flow rate is low after UUO, the amount of sodium passing through the distal nephron is also decreased during UUO, and the normal potassium secretory mechanism has been interfered with directly as a result of mechanical obstruction. These explanations are supported by the work of Thirakomen and associates (1976), who showed a persistent decrease in absolute potassium excretion despite volume expansion or sodium sulfate administration. These two maneuvers increase distal sodium delivery, but they do not increase the excretion of potassium; this action lends support to the hypothesis of a defect in the distal secretory mechanism of potassium as the cause for the decreased excretion of potassium from the post-UUO kidney.

DURATION OF OBSTRUCTION:

The degree of recovery of renal function after release of unilateral ureteric obstruction correlates inversely with the duration of obstruction ⁽³⁰⁾ . In dogs, there was rarely return of function with release of obstruction after 40 days⁽³¹⁾ Function has been reported to return in clinical cases after more than 150 days of complete obstruction⁽³²⁾

The reason for lack of correlation between experimental data and clinical situation is that the complete occlusion of ureter by ligation is not comparable to the incomplete occlusion that is more likely in PUJO.

FUNCTION OF CONTRALATERAL KIDNEY :

In the past, theories of renal counter balance and renal disuse atrophy have considerably affected the treatment options for PUJO. There was a progressive loss of renal function (measured by ^{99m}Tc -DTPA scans and creatinine clearance) with increasing periods of obstruction. Early work by Hinman (1943) suggested that in order for an obstructed kidney to recover, contralateral nephrectomy would be necessary. ⁽³³⁾ The rationale for this concept is the observation that the contralateral kidney undergoes compensatory hypertrophy after UUO. Hinman proposed the term *renal counterbalance* to describe the phenomenon. **He postulated that the injured kidney would undergo "disuse atrophy" and would not recover after repair because of the presence of the enlarged healthy mate..**

It was commonly thought that once hypertrophy of opposite kidney occurs fully, the damaged kidney would not regain its function. Hydronephrotic atrophy was considered complete in 6 months and compensatory hypertrophy complete in 4-6 weeks ⁽³⁴⁾. Animal and human experiments have challenged this theory and it is now well established that recovery of even a poorly functioning kidney is possible, despite compensatory hypertrophy of opposite kidney.

ULTRA SONOGRAM

A renal sonogram is a good starting point for evaluating the renal units of patients who have azotemia, have contrast material–induced allergy, are pregnant, or are in the pediatric age group. Significant information can be obtained about both the renal parenchyma and the collecting system with no exposure to radiation and no contrast material–induced nephrotoxicity or anaphylaxis.

Hydronephrosis appears as a dilated collecting system separating the normally echogenic renal sinus, creating an anechoic central area surrounded by parenchyma. Echoes within the collecting system may indicate an infection (pyonephrosis), hemorrhage, or a lesion of the transitional mucosa, among other diagnoses. The thickness of the renal parenchyma can be measured as an indicator of the duration of obstruction; the degree of hydronephrosis should not be equated with the duration of the obstruction.

There are several pitfalls to the use of ultrasonography for diagnosing obstruction.

Both the underdiagnosis of hydronephrosis—that is, missing an obstruction (false-negative)— and the overdiagnosis of obstruction owing to the presence of

hydronephrosis (false-positive) are possible. Sonograms can be false-negative as a result of an acute onset of obstruction, an intrarenal collecting system, dehydration, and

the misinterpretation of caliectasis as renal cortical cysts. Sonograms can be false-positive for obstruction as a result of a capacious extrarenal pelvis, parapelvic cysts, vesicoureteral reflux, and a high urine flow state (Talner, 1990a, b) ⁽³⁵⁾ . Therefore, although the sonogram is an excellent tool for the initial evaluation of selected patients with suspected renal obstruction, it should be interpreted carefully and must be consistent with the overall clinical picture.

Laing and colleagues (1985) performed a prospective study of 20 patients to evaluate the usefulness of ultrasonography versus excretory urography in patients with acute renal colic ⁽³⁶⁾ . Ultrasonography failed to detect hydronephrosis in 7 of 20 patients (35%) with proven acute obstruction on excretory urography. These investigators concluded that, although ultrasonography may be useful for the evaluation of hydronephrosis in the chronically obstructed kidney, it may not be efficacious in the evaluation of patients with acute urinary obstruction. **Accordingly, if a patient is initially evaluated for obstruction with ultrasonography and findings are negative but symptoms persist, excretory urography should follow.**

In order to identify intermittent obstruction as a cause of flank or abdominal pain that is episodic, studies should be obtained while the patient is experiencing symptoms

DIURETIC RENOGRAM

The diuretic renogram is becoming more widely utilized than excretory urography for evaluation of the dilated collecting system. It provides a noninvasive measure of the relative renal function and has the ability to wash out the radiopharmaceutical agent from the dilated collecting system. There is a marked reduction in radiation dose in comparison with excretory urography, and there is no potential for contrast material–induced nephrotoxicity (Taylor and Nally, 1995). ⁽³⁷⁾

The most widely used radiopharmaceutical agents are (1) tubular tracers—orthoiodohippurate I-131 (¹³¹I-OIH) and technetium Tc 99m mercaptoacetyltriglycine (^{99m}Tc- MAG3)—and (2) glomerular tracers, namely technetium Tc 99m diethylenetriaminepenta-acetic acid (^{99m}Tc-DTPA). For evaluating obstruction, the radiopharmaceutical agent of choice today is ^{99m}Tc-MAG3, because it is more efficiently extracted by the kidney than is ^{99m}Tc-DTPA, delivers a lower dose of radiation to the obstructed kidney than does ¹³¹I-OIH, and is excreted by the same portion of the tubule

that responds to furosemide (Taylor and Eshima, 1988; Taylor and Nally, 1995). ^{99m}Tc -MAG3 has been shown to provide better counting statistics and visualization of the anatomy of obstruction than do ^{131}I -OIH and other radiopharmaceutical agents (Eshima and Taylor, 1992). ⁽³⁸⁾

When diuretic renography is performed, the technique of patient preparation and the timing of the administration of the diuretic are extremely important. The patients should be well hydrated before the procedure. An IV line may be started before the procedure to initiate hydration (Conway, 1992; Taylor and Nally, 1995). Patients who can void spontaneously do not require bladder catheterization. Those who cannot void spontaneously do require bladder catheterization (1) to ensure adequate bladder drainage, (2) to reduce false-positive results, and (3) to decrease the radiation dose to the bladder and gonads. The patient's renal function is extremely important when the results from a diuretic renogram are interpreted. **The ability of the kidneys to generate a sufficient diuretic-induced flow rate to detect renal obstruction depends on the patient's creatinine clearance.** In the presence of a reduced creatinine clearance, it may be necessary to increase the diuretic dose to achieve an adequate flow rate and reduce the possibility of a false-negative result (Upsdell et al, 1988).

The timing of the administration of the diuretic after the administration of the radiopharmaceutical agent has been carefully worked out. Brown and coworkers (1992)

determined that the urinary flow rate is 3.5 ml/min greater at 15 to 18 minutes after IV furosemide administration than at 3 to 6 minutes after the administration of a diuretic (Fig. 12-3). **The traditional diuretic renogram is obtained by administering the radiopharmaceutical agent and obtaining images, followed 20 minutes later by IV administration of the diuretic, and then measuring the $T_{1/2}$ for the clearance of the tracer from the collecting system.** O'Reilly and associates referred to this technique as the F+20 diuretic renogram (O'Reilly et al, 1979; O'Reilly, 1992) ⁽³⁹⁾ . Figure 12-4 depicts the various outcomes from the F+20 diuretic renogram. **The diagnostic dilemma arises with the patients who show a partial excretory response; this indicates either an inability to excrete the radioisotope because of poor renal function or a truly partially obstructed system** (group IIIa in Fig. 12-4). Upsdell and associates (1988) were able to convert this equivocal response to the diuretic into a washout response by administering the diuretic 15 minutes before administering the radiopharmaceutical agent (i.e., F-15) ⁽⁴⁰⁾ . Some centers routinely use the F-15 technique for diuretic renography when renal obstruction is suspected. Others use the F+20 technique for their routine diuretic renograms, reserving the F-15 technique for use when the F+20 method demonstrates partial obstruction.

Data from the diuretic renogram can be interpreted either visually or by quantitative measurements of the $T_{1/2}$ diuretic response (Conway, 1992). Many factors influence the $T_{1/2}$, including

(1) renal function, which includes the level of renal maturity;

(2) the compliance of the collecting system;

(3) the volume of the collecting system;

(4) the hydration of the patient;

(5) the presence or absence of a bladder catheter;

(6) the radiopharmaceutical agent; and

(7) the dose of the diuretic (Fine, 1991; Taylor and Nally, 1995).

It is generally accepted that a clearance of the radiopharmaceutical agent from the renal pelvis with a $T_{1/2}$ of less than 10 minutes is normal; some experts consider a $T_{1/2}$ of less than 15 minutes normal. Clearance of tracer with a $T_{1/2}$ between 15 and 20 minutes is considered equivocal, and a $T_{1/2}$ greater than 20 minutes indicates an obstruction (O'Reilly, 1986; Taylor and Nally, 1995).

RESISTIVE INDEX

The use of duplex Doppler ultrasonography for evaluation of the kidney allows the determination of the renal resistive index (RI) where

$$RI = ([\text{peak systolic velocity}] - [\text{lowest diastolic velocity}]) / [\text{peak systolic velocity}]$$

(Cronan, 1991; Cronan and Tublin, 1995).

A value of 0.7 has been taken as the upper limit of normal (Platt et al, 1991) ⁽⁴¹⁾. RIs above 0.7 are used for the diagnosis of obstruction, although higher-than-normal RIs are not limited to obstruction, inasmuch as medical renal diseases alone can also cause the RI to exceed 0.7. An RI in the obstructed kidney that is 0.1 greater than the RI in the contralateral kidney is considered to be significant enough to indicate obstruction. There is much controversy in the literature regarding the use of the RI in diagnosing obstruction. Platt and coworkers (1993) presented data on 23 patients with acute UUO of 36 hours' duration or less, measuring the renal RI in the "obstructed" and the contralateral renal units. The mean RI in the obstructed kidney was 0.77, as than 0.7, two had pyelosinus extravasation and one had obstruction for less than 4 to 5 hours. Because the vasoconstriction of UUO occurs after 5 to 6 hours, the RI may not rise until renal obstruction has been present for at least 5 to 6 hours. Platt and coworkers (1993)

concluded that Doppler determination of renal RIs is a valuable addition for improving the accuracy of routine renal ultrasonography in the diagnosis of renal obstruction in patients presenting with acute renal colic and for whom an IVU is not desirable (e.g., pregnant patients and patients with a history of contrast material–induced allergy or renal failure).

Other investigators believe there is no role for the use of duplex Doppler sonography in the detection of acute renal obstruction (Tublin et al, 1994; Cronan and Tublin, 1995) ⁽⁴²⁾. Tublin and coworkers (1994) evaluated 32 patients with acute renal colic. Twelve of the obstructed kidneys had a mean RI of less than 0.7, and 7 of the nonobstructed kidneys had a mean RI of greater than 0.7. Using an RI of greater than 0.7 as diagnostic of acute renal obstruction, Tublin and coworkers (1994) determined that the sensitivity and specificity of duplex Doppler sonography were 37% and 84%, respectively. When using an RI difference greater than 0.1 between the ipsilateral and the contralateral renal units to diagnose obstruction, they determined that the sensitivity and specificity were 37% and 100%, respectively. The difference in clinical findings between the two previous studies may result from several factors, including (1) the quality of the examination and the Doppler waveform analysis, (2) the duration of obstruction, (3) the presence of a fornix rupture and extravasation, and (4) the degree of obstruction. Finally, Tublin and coworkers (1994) pointed out that the initial management of the acute renal colic with nonsteroidal anti-inflammatory drugs (NSAIDs) could alter the intrarenal

vascular tone and hence affect the RI. . In three obstructed kidneys with an RI of less Chen and coworkers (1993) showed that the degree of renal obstruction affects the renal RI. Mildly obstructed kidneys had a mean RI of 0.64, as opposed to 0.74 for the severely obstructed kidneys. Three of five kidneys with a prerelease RI of greater than 0.7 had a follow-up RI of less than 0.7 within 3 days after the relief of obstruction. Prerelease RIs of less than 0.7 in two renal units remained less than 0.7 after relief of the obstruction. There may be clinical utility in using the RI to decide which patients with hydronephrosis would benefit from surgical intervention to improve RBF and hence preserve renal function. Fung and colleagues (1994) demonstrated a relationship between elevated intrarenal RIs and elevated intrapelvic pressures ⁽⁴³⁾ .An elevated intrarenal RI may be able to distinguish obstructive and nonobstructive hydronephrosis. This would indicate which patients will benefit from surgical intervention to preserve and, it is hoped, improve renal function in the future.

Other studies by Shoekir et al ⁽⁴⁴⁾ showed that pre-release RI cannot be used to assess salvagability –in experimental setup.

Normal adult RI	0.57-0.64
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Children RI	Still not established <4 yrs RI 0.70 may be Normal
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Diagnostic Accuracy in adults

Platt et al concluded that

Sensitivity of **92%**, Specificity of **88%** and over all accuracy of **90%**

Causes of false positive results :

1. Abnormalities of BP and pulse rate
2. Children-not standardized
3. dehydration
4. Medical renal diseases

Causes of false negative results :

1. Acute obstruction

2.Mild obstruction

Markedly dilated system-Plat et al found that in marked dilated system ,kidneys did not show an increase in RI ,probably due to

- a.marked decrease in RBF
- b.decreased filtration pressure
- c.elevated compliance in huge dilatation
- d.tracing the vessels may be difficult

RI accuracy can be increased by

- 1.Comparison to opposite kidney-RI ration >1.1 is significant
- 2.Diuresis RI
- 3.Comparison to opposite kidney with diuresis

Prediction of renal function- Recent studies have shown that RI cannot predict the recoverability of renal function. It was seen that reversal of RI after relief of obstruction can be early sign of recoverability

Relation ship between RI and T1/2 on Diuretic renogram-

It was observed that patients with T1/2 < 10 min always had RI <0.68 and can be followed up with serial RI

PERCUTANEOUS NEPHROSTOMY (PCN)

A PCN may be performed pre-operatively to assess the recoverability of function of the obstructed kidney. Ransley et al⁽⁴⁵⁾ studied newborns with PUJO and poor renal function by inserting pigtail nephrostomy tube. The patients underwent a repeat DTPA diuretic renogram and proceeded to nephrectomy, if GFR is still <10%. Upto a third of cases in this series showed recovery of function to substantiate pyeloplasty. These authors recommended that nephrectomy should not be performed without a period of PCN drainage. The same authors now proceed to nephrectomy, if GFR <10%.

Gillenwater et al ⁽⁴⁶⁾ – the best method to assess the recoverability is to relieve the obstruction and follow the improvement in creatinine clearance. But the value of Creatinine clearance, indicative of salvagability, is not clear. Cronan et al ⁽⁴⁷⁾ – suggested sufficient time to allow recovery. He suggested at least 8 weeks for optimization of basal renal function. Various authors suggest variable time, varying from 3- 6 weeks.

The quality of urine produced is equally important. Production of large volume dilute, poor quality urine does not contribute to renal functional reserve. Hence it needs to be good quality urine, to indicate salvagability.

Tubular damage after chronic obstruction is an important prognosticator of salvagability. Tubular functions of acidification, Na retention and specific gravity are easily assessable parameters.

Surgical exploration

Bassiuny et al ⁽⁴⁸⁾ reported their experience that only assessment of renal tissue during surgical exploration can sufficiently prognosticate the salvagability of kidney. Overall bulk as well as thickness of parenchyma can be assessed. He reported 100% increase in GFR after pyeloplasty for selected cases (these children had initial GFR < 10%)

Other experimental indicators –

1.Enzymuria – NAG enzyme / Gamma-GT

2.TGF-B

Renal Biopsy- There are only 3 studies correlating biopsy changes with salvagability.Kruger ⁽⁴⁹⁾ et al studied the biopsy changes of chronic obstruction and GFR based on diuretic renogram.They found discrepancy in 25 % of cases.75% of severe changes in biopsy had poor function on DTPA>They graded biopsy changes as 1-4.Grade 3 or 4 changes were associated with GFR <15% in 80% of cases.Prospective studies are required to validate the usefulness of histological changes in assessing the salvagability of chronically obstructed kidney.

Estimation of renal parenchyma-

One of the arbitrary criteria used to indicate the salvagability is measurement of parenchymal thickness,as measured by USG.It has been estimated that a parenchymal thickness of > 1 cm augurs good prognosis..However ,in hydronephrotic kidneys,the parenchymal thickness is irregular and measuring it at one or more points does not reflect the true amount of functioning nephrons.It was proposede that measuring the

whole volume by CT may be a better tool. Combining renal biopsy with thickness estimation may be better to assess the salvagability of the kidney

Renal functional reserve –

The concept of renal functional reserve assesses the renal response to stress. Basal renal function is estimated by DTPA. the renal response to stress like amino acid load, dopamine injection and diuresis is documented with repeat DTPA. The practical calculation is difficult and application in a patient scenario is found to be difficult. Hence, at present, the status is experimental.

ESTIMATION OF GFR

Estimates of GFR are the best overall indices of the level of kidney function.

The level of GFR should be estimated from prediction equations that take into account the serum creatinine concentration and some or all of the following variables: age, gender, race, and body size. The following equations provide useful estimates of GFR:

- In adults, the MDRD Study and Cockcroft-Gault equations ⁽⁵¹⁾
- In children, the Schwartz and Counahan-Barratt equations⁽⁵²⁾
- The serum creatinine concentration alone should not be used to assess the level of kidney function.
- Clinical laboratories should report an estimate of GFR using a prediction equation, in addition to reporting the serum creatinine measurement.
- Autoanalyzer manufacturers and clinical laboratories should calibrate serum creatinine assays using an international standard.

Measurement of creatinine clearance using timed (for example, 24-hour) urine collections does not improve the estimate of GFR over that provided by prediction equations. A 24-hour urine sample provides useful information for:

- Estimation of GFR in individuals with exceptional dietary intake (vegetarian diet, creatine supplements) or muscle mass (amputation, malnutrition, muscle wasting);
- Assessment of diet and nutritional status;
- Need to start dialysis.

Background

Glomerular filtration rate (GFR) provides an excellent measure of the filtering capacity of the kidneys. A low or decreasing GFR is a good index of chronic kidney disease. Since the total kidney GFR is equal to the sum of the filtration rates in each of the functioning nephrons, the total GFR can be used as an index of functioning renal mass⁽⁵⁰⁾. A decrease in GFR precedes kidney failure in all forms of progressive kidney disease. Monitoring changes in GFR can delineate progression of kidney disease. The level of GFR is a strong predictor of the time to onset of kidney failure as well as the risk of complications of chronic kidney disease. Additionally, estimation of GFR in clinical practice allows proper dosing of drugs excreted by glomerular filtration to avoid potential drug toxicity.

Glomerular filtration rate cannot be measured directly. If a substance in stable concentration in the plasma is physiologically inert, freely filtered at the glomerulus, and neither secreted, reabsorbed, synthesized, nor metabolized by the kidney, the amount of

that substance filtered at the glomerulus is equal to the amount excreted in the urine. The fructose polysaccharide inulin has each of the above properties and has long been considered an ideal substance to estimate GFR. The amount of inulin filtered at the glomerulus equals the GFR multiplied by the plasma inulin concentration: $GFR \times P_{in}$. The amount of excreted inulin equals the urine inulin concentration (U_{in}) multiplied by the urine flow rate (V , volume excreted per unit time).

Since filtered inulin = excreted inulin:

$$(1) \quad GFR \times P_{in} = U_{in} \times V$$

$$(2) \quad GFR = \frac{U_{in} \times V}{P_{in}}$$

Measuring 24-hour creatinine clearance to assess GFR is not more reliable than estimating GFR from a prediction equation (R). A 24-hour urine collection is useful for measurement of total excretion of nitrogen, electrolytes, and other substances. However, the use of 24-hour urine collection for the estimation of GFR has consistently been shown to be no more, and often less, reliable than serum creatinine based equations. A 1998 review found five of six studies that found serum creatinine based estimates of GFR to have a lower error than measured creatinine clearance in patients with kidney

disease. In addition to collection errors, this is attributed to diurnal variation in GFR and day-to-day variation in creatinine excretion

Estimation of GFR or creatinine clearance from serum creatinine is critically dependent on calibration of the serum creatinine assay (R). There is substantial variation across laboratories in the calibration of serum creatinine, with systematic differences as large as 0.2 to 0.4 mg/dL not being uncommon

Serum creatinine alone is not an accurate index of the level of GFR (R).⁽⁵³⁾

The use of the serum level of creatinine as an index of GFR rests on three important assumptions: (1) creatinine is an ideal filtration marker whose clearance approximates GFR; (2) creatinine excretion rate is constant among individuals and over time; and (3) measurement of serum creatinine is accurate and reproducible across clinical laboratories. Although the serum creatinine concentration can provide a rough index of the level of GFR, none of these assumptions is strictly true, and numerous factors can lead to errors in estimation of the level of GFR from the serum creatinine concentration alone.

Among adults, the MDRD Study equation provides a clinically useful estimate of GFR (up to approximately 90 mL/min/1.73 m²) (S).

Among children, the Schwartz and Counahan-Barratt formulae provide clinically useful estimates of GFR (C).

Creatinine clearance over-estimates GFR; therefore, equations that accurately estimate creatinine clearance overestimate GFR when true creatinine is measured (R, S). Estimation of GFR or creatinine clearance from serum creatinine is critically dependent on calibration of the serum creatinine assay (R).

Single kidney Creatinine clearance = $U_{Cr} / P_{Cr} \times V$

Since the quantity and quality of urine from PCN gives good objective assessment of renal function, we have not included Cr Clearance in this study

COMPARISON OF VARIOUS FACTORS FOR ASESING SALVAGABILITY

S.No	Investigation	Advantages	Disadvantages
1.	Ultrasound	-Simple -Accurate diagnosis of PUJO -Parenchymal thickness	-Subjective -No functional asesment
2.	IVU	-Functional + anatomical study	-contrast reactions -Nonvisualisation not same as nonfunctioning
3.	Doppler	-Measurement of RI -Usefulin acute obstruction	-Tracing arteries in giant HN is difficult -Cutoff value 0.7 arbitrary
S.No	Investigation	Advantages	Disadvantages

4.	DTPA	<ul style="list-style-type: none"> -useful even in children -functional assessment -baseline function for later follow-up -differential function 	<ul style="list-style-type: none"> -Needs tempering for optimum result - Expensive -10-15% false positive rates
5.	Percutaneous Nephrostomy	<ul style="list-style-type: none"> -objective assessment -assess quantity & quality of urine 	<ul style="list-style-type: none"> -Invasive -sepsis -bleeding -difficult mobilization during surgery

AIM AND OBJECTIVE

- 1. To assess the salvagability of Giant hydronephrosis ,non visualized on IVU,using percutaneous nephrostomy**
- 2. To compare various parameters used to estimate the recoverability of renal function**

MATERIAL AND METHODS

Period of study – Aug 2005 to May 2008 (34 months)

No. of patients studied – 24

No.of Bilateral PUJO – 1

No.of unilateral PUJO -23

Male : female = 12:12

Right : left = 11 : 13

Age range from 13-46 years (average 26 years)

The patients are stratified based on age group into

A. Age <20 yrs

B. Age 20-40 years

C. Age > 40 years

Presentation : Loin pain

Loin mass

Non specific symptoms

Sepsis

Investigations : 1.Hemogram

2. renal function test

3.USG KUB

4. X-ray KUB

5. IVU

6. Doppler USG for RI

7. Diuretic renogram

Inclusion criteria :

1. All giant hydronephrosis ,non visualized on IVU
2. Patients counseled and patients giving consent for PCN were selected for study.
3. patients ,who did not consent for PCN underwent nephrectomy.

PERCUTANEOUS NEPHROSTOMY

1. Patient is counselled thoroughly about the procedure, the aim of PCN, duration of PCN, its complications and alternatives
2. Informed consent is obtained
3. Patient is made to lie down prone, with a sandbag under ipsilateral half of abdomen. Inj Cefotaxime 1.0 gm IV ATD given
4. Preliminary USG is done to assess the degree of dilatation, cortical thickness, depth and angulation from skin, shortest possible route.
5. Puncture site is planned behind posterior axillary line, below and medial to the 12th rib tip- adjusting to the shortest route.
6. Betadine painting and draping is done. Skin and subcutaneous tissue is infiltrated with 1% lignocaine. 5mm incision is made and depth increased till

the muscle layers are cut

7. Single step 8.5 Fr pigtail PCN catheter is used for puncture.

8. Periodical USG guide used to track the needle path

9. Once collecting system is confirmed by urine in the stilette, the catheter is advanced into PCS and fixed to skin

10. Catheter position is confirmed by USG

Observation is made regarding

1. Quality of Urine – pus, turbid, clear, blood stained
2. Quantity – drained after puncture immediately
3. Vitals of patient checked

As in the Proforma,

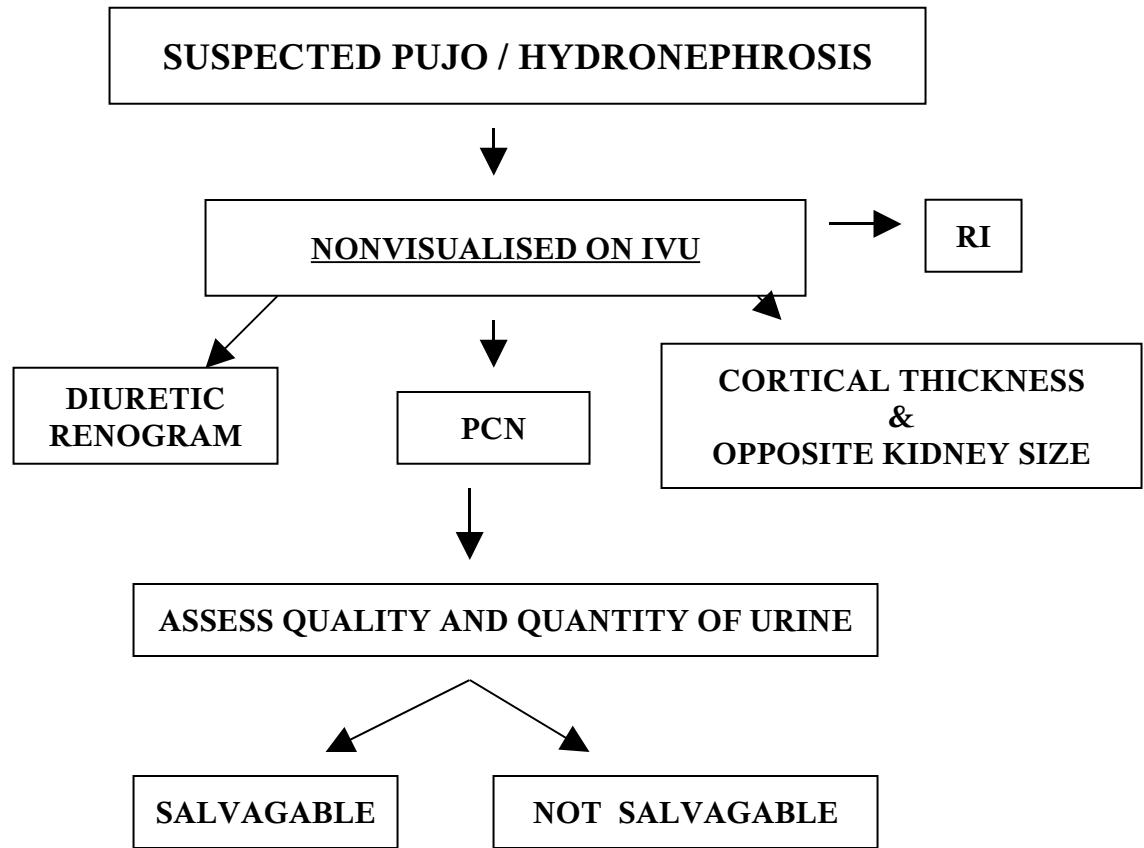
Daily PCN and Urine output chart is maintained for 2 weeks.

If quantity is satisfactory (> 500 ml), Quality of urine is assessed by.

- a. pH
- b. Osmolarity
- c. Specific gravity
- d. Spot Na
- e. Culture and sensitivity

S.No	Investigations	Favourable values	Un- favourable values	Significance
1.	pH	< 6.5	>7.0	1. Loss of acidification function of tubule 2.Rule out infection as the cause of alkaline Urine
2.	Osmolarity	50-1200 mOsm/kg	<300 esp after overnight dehydration	Index for concentrating ability of kidney
3.	Specific gravity	1010-1030	Fixed 1010	Loss of concentrating capacity
4.	Spot Na	< 40 meq/l	>60 meq/l	Na leak due to defective

				tubular function
5.	Urine culture	No Growth	Growth present	Requires treatment of active infection



INFORMED CONSENT FORM

I am _____ willing to participate in the study titled

Salvagability of Giant hydronephrosis ,Non Visualised on IVU

. I am aware that I will be undergoing various tests to study my kidney function.Lastly a tube will be placed in my affected kidney to assess whether it is advisable to repair the block.The final decision to remove affected kidney or repair it ,will be based on the results.The complications and other details have been extensively discussed with me. The purpose and the advantage of the study has been explained in the mother tongue by the investigator. I am also aware that I can discontinue from the study whenever I wished to do so.

Date;

Place;

Signature of the Patient/Guardian

TREATMENT PROTOCOLS

1.Salvagable kidney-

a. Pyeloplasty

b. Ureterico calycostomy

based on the anatomy

2.Non salvageable kidney –

Nephrectomy (open procedure)

RESULTS

SIDE OF OBSTRUCTION

Side	No. of cases	No. of cases salvaged
Left	13	5
Right	11	2

One case – Bilateral PUJO

AGE (DURATION OF OBSTRUCTION) AND SALVAGABILITY

Category	Age gp (yrs)	No.of cases	No.of cases Salvaged	% of Salvagability
A	<20	6	3	50
B	20-40 yrs	14	4	28.5
C	>40 yrs	4	0	0

SEX OF THE PATIENT

Sex	No. of cases	Salvaged cases
Male	12	4
Female	12	3

COMPENSATORY HYPERTROPHY AND SALVAGABILITY

Category	No. of cases	No. of Salvaged cases	<u>% of Salvagability</u>
Opposite kidney Hypertrophy	8	3	37.5
Opposite kidney Normal	15	3	20

One case of Bilateral PUJO not included in this analysis

RENAL RESISTIVE INDEX AND SALVAGABILITY

RI	No. of cases	Salvaged	Not salvaged	% of salvagability	% not salvaged
<0.70	7	1	6	14	86
> 0.70	17	6	11	4	50

CORTICAL THICKNESS AND SALVAGABILITY

Category	No of cases	No of cases salvaged	% of salvagability
No appreciable / thin cortex	16	4	25
Cortex seen 0.5-1 cm	8	4	50

DIURETIC RENOGRAM AND SALVAGABILITY

Split GFR (ml/min)	No. of cases	No. of cases Salvaged	No. of cases not Salvaged
< 10	1	1	0
10-20	16	4	12
>20	7	2	5

PROTOCOL

Protocol	No. of cases
F -20	7
F + 0	17

Curve – obstructed in all cases

Pre PCN Salvagability

Factor	Good	Poor
Cortical thickness	>0.5 cm	No cortex
RI	<0.70	> 0.70
Opposite kidney	Normal size	Increased size
DTPA (Split GFR)	>20 (children >10)	< 20 (children< 10)

PCN FLUID ANALYSIS in patients with good PCN output

No. of cases with good output	– 13
No. of cases with good quality urine	– 9
No. of cases with poor quality urine	– 4
No . of cases with salvageable kidneys , but sacrificed due to secondary infection	– 2

Pre PCN salvagability (atleast 2 indices favorable)		Post PCN salvagability		Salvaged	Not salvaged
Good	10	Good	5	3	2 (PYONEPHROSIS)
		Poor	5		
Poor	14	Good	4	4	0
		Poor	10		

No. of cases with favorable salvagability Pre PCN - 10

No. of cases deemed not salvageable after PCN – 05

No. of cases with un favorable salvagability Pre PCN – 14

No. of cases deemed salvageable after PCN – 4

No. of cases in which PCN altered the treatment - 9 / 24
= 38%

TREATMENT

Nephrectomy – 15 cases nonsalvagable kidney
2 cases due to pyonephrosis

Dismembered pyeloplasty – 5 cases

Ureterocalicostomy – 2 cases

FOLLOW-UP

Period of follow up 3 months to 22 months

No. of salvaged cases followed up – 7

Lost follow up 1 case

Other cases followed with

- 1. Symptom score**
- 2. USG**

3. Renal function test

4. Diuretic renogram for

drainage and GFR

Ultrasound- All patients had residual dilatation of the collecting system

Drainage as seen in Diuretic renogram improved in all patients

GFR improved by 12 % - one patient

Remained almost same – six patients

SUMMARY OF RESULTS

1.Side of obstruction was not significantly related to salvagability of the kidney

2..Based on age groups ,patients were classified into A (<20yrs),B (20-40 yrs) and C (> 40 yrs).Most of our patients were in B category. Consistent with literature ,most cases presented in middle age .The salvagability of the kidney was related to duration of obstruction (age of the patient).While 50% of A was salvageable ,none of C category (>40 yrs) were salvageable

3. Sex of the patient was found to be insignificant with regards to salvagability

4.Presence of compensatory hypertrophy did not significantly affect the salvagability. In our study, 37.5% of patients with compensatory hypertrophy were salvageable ,while only 20% of patients with normal opposite kidneys were salvageable.

5 .Cortical thickness assessment by Ultrasonogram is highly subjective. In our study 25% of kidneys with no demonstrable cortex were salvageable

.Good cortical thickness predicted better salvagability (50%).Hence cortical thickness has good positive predictive value.

6.Resisitve index had poor predictive value in our study.While 35% of kidneys with $RI > 0.7$ were salvageable, kidneys with good $RI < 0.7$ –only 14% were salvageable.

7.In our study, we found GFR assessment based on nuclear study was not correlating with salvagability.Even kidneys with $GFR > 20 \text{ ml/min-5 / 7}$ cases were not salvageable.This may be due to variations in protocols and technical differences(multi-institutional results)

8.Based on these initial parameters ,patients were roughly categorized into good and poor salvagability groups.PCN was done for all patients.

8.Kidneys with favorable parameters- (10) -5 of these were of poor category after PCN.2 patients with good salvagability post PCN developed pyonephrosis and underwent nephrectomy

9.Even in kidneys thought not salvageable,PCN showed that 4/14 were salvageable.

10.Overall PCN altered management in 38% of the patients

CONCLUSION

Although PUJ obstruction is usually a congenital obstruction, it commonly manifests in middle age. Salvagability of kidney after chronic obstruction has been extensively studied in pediatric population. Renal changes after ureteric obstruction has been studied extensively in animal models, especially in acute setting. Extrapolation of these findings to adult setting has its own disadvantages.

All the regular parameters like cortical thickness, compensatory hypertrophy, Diuretic renogram, Resistive index are not without pitfalls. Predicting the salvagability of chronically obstructed kidneys based on single parameter or combined parameters can be misleading. Percutaneous nephrostomy is a simple, objective assessment of the kidney function. In our study, it has altered the management in 38% of patients.

Based on our analysis, it can be safely concluded that **Percutaneous nephrostomy is a useful tool in accurate assessment of chronically obstructed kidneys.**

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SALVAGABILITY OF PUJO KIDNEY PROFORMA

Name - Age/Sex IP- D.O.A

Address- D.O.D

COMPLAINTS-

PRESENT H/O –

PAST H/O –

O/E-

CLINICAL DIAGNOSIS-

INVESTIGATIONS-

Hb-	ECG	DOPPLER (RI)
Bld sugar	CXR	
Bld urea	Xray KUB	
S.Crea		

TC	USG KUB
DC	
ESR	

Urine R/E	CT KUB
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Urine C/S

Blood Gp	DIURETIC RENOGRAPH
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FINAL DIAGNOSIS-

Under LA,USG guided ----- sided PCN done on -----

DAY POST PCN	PCN OUTPUT	URETHRAL FOLEY U/O

PCN FLUID - pH Osmolarity Spot Na –

PLAN –

PROCEDURE DONE-